Some physics result highlights from NUINT15 … with a DUNE-ish perspective

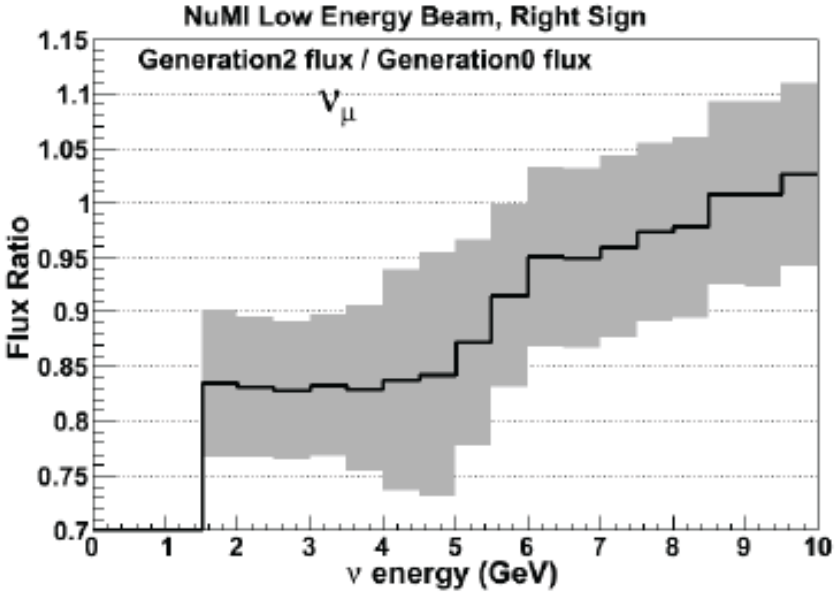
- S. Manly
- Univ. of Rochester

- DUNE LBPWG 11/24/2015

No serious attempt to be inclusive.
Personal bias + jetlag … mostly accelerator neutrino experimental

MINERvA and flux update
(T. Golan: new NuMI flux model, M. Betancourt: effect on CCQE results)

- We have a new flux with improvements, main changes to beamline geometry and updates to the simulation (simulation has been constrained to hadron production data)
- Comparison of the new vs old flux for neutrinos (old flux=flux from 2013 publication)



Systematic uncertainties for the new flux are smaller

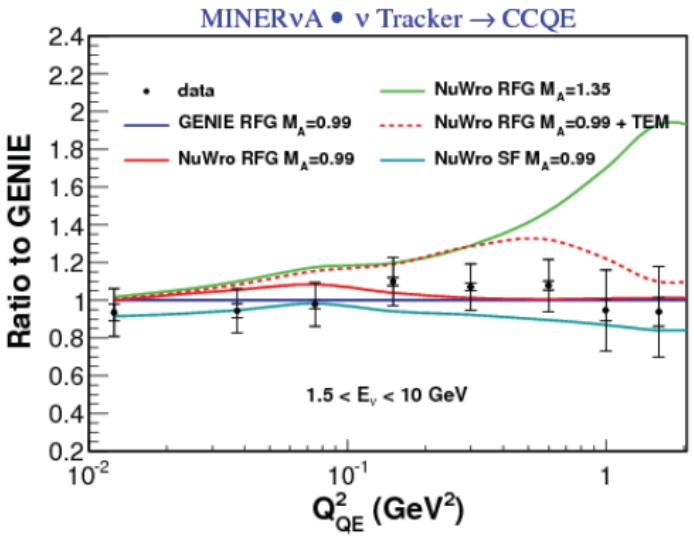
Shifts in CCQE dsigma/dQ2 of 20%

CC0pi with nue scattering flux constraint 5%

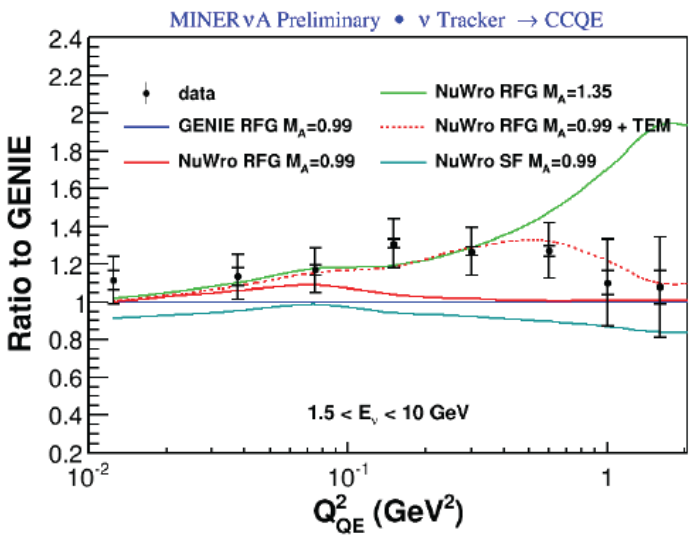
Other things will shift by 10% ish

Integrated uncertainties will drop some

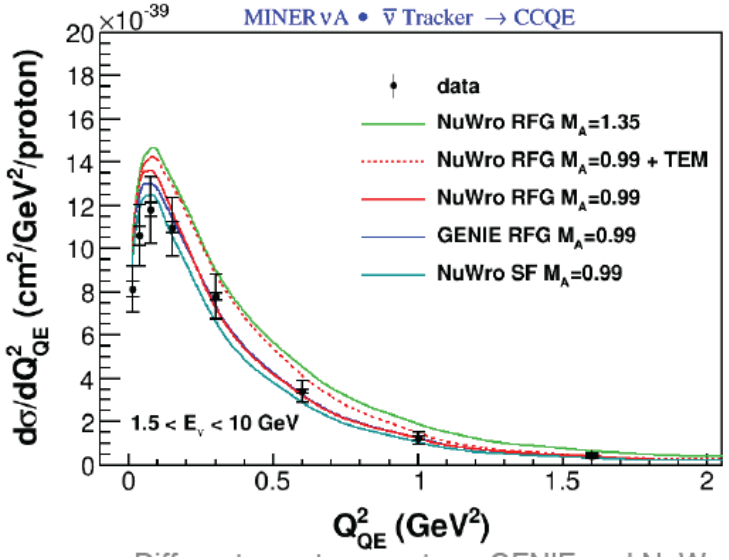
Phys. Rev. Lett. 111, 022501 (2013)



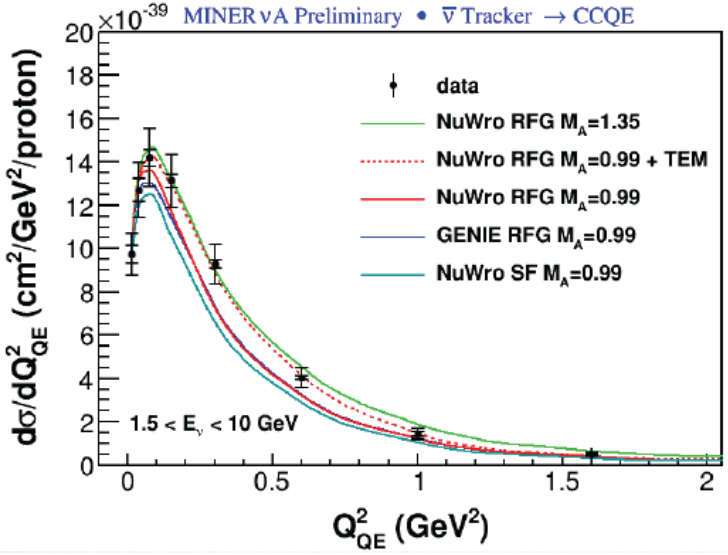
2013 Measurement with updated flux



Phys. Rev. Lett. 111, 022502 (2013)



2013 Measurement with updated flux



Note that flux change is significant when compared to models for both neutrinos (top) and anti-neutrinos (bottom)

Fairly strong preference for NuWro with Transverse Enhancement Model with MA=0.99

TEM is empirical model where magnetic form factors of bound nucleons are tuned to reproduce enhancement in the transverse xsec in eA scattering which is attributed to meson exchange currents in the nucleus

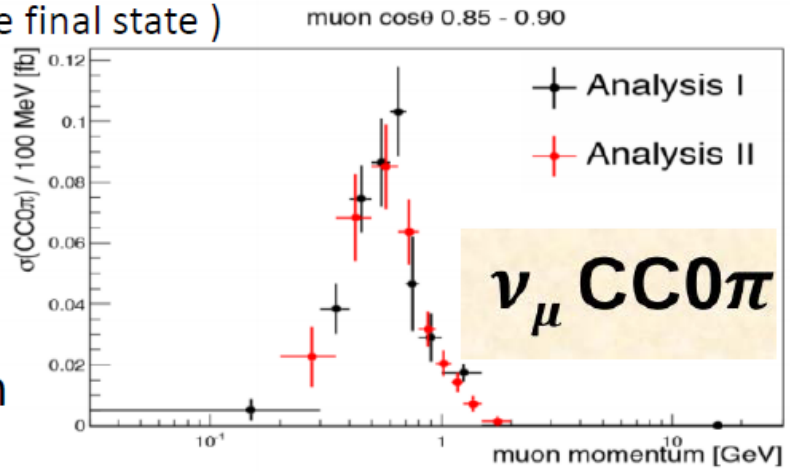
A. Bodek, H. Budd, M. Christy, Eur. Phys. J. C71, 1726 (2011)

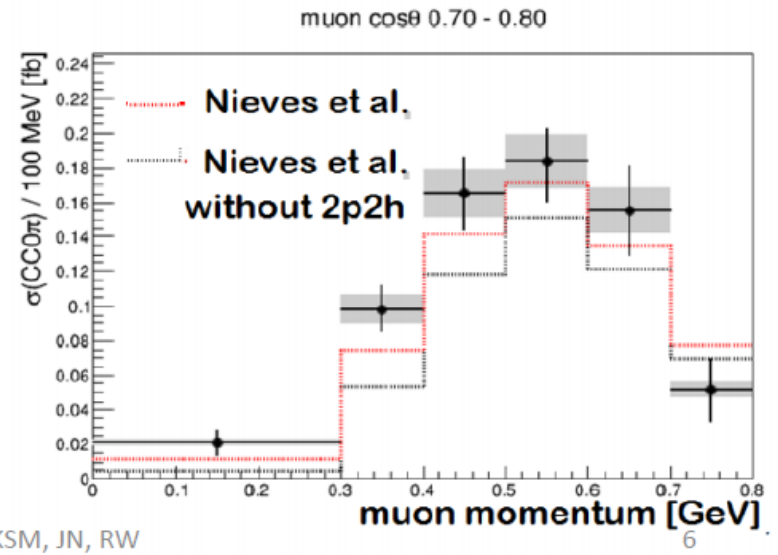
T2K Low Energy CC0pi

Redij

(muon + no pions in the final state)

- Two ND280 analyses, with separate selections (70% overlapping) and cross section calculation methods
  - with and without information from proton in final state
  - consistent results! Check of model independence
  - Confront with data
- Preference for 2p2h contributions in regions preferred by Nieves model
  - More data (RHC?) desired!





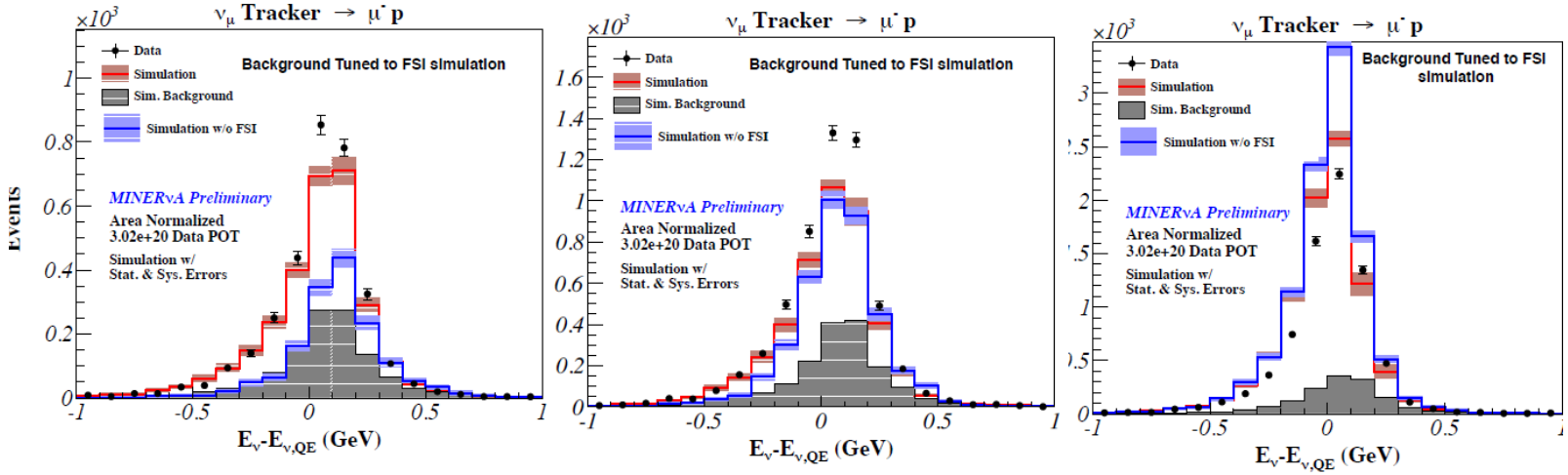
From McFarland's QE summary

Start to see a theme??

MINERvA CCQE-like with one muon and one proton Looking in bins of acoplanarity angle (Betancourt)

Neutrino Energy(proton+muon) - Neutrino from QE Hypothesis

- Neutrino energy prediction differences
  - E_ν is reconstructed using the muon and proton information
  - $E_{\nu,QE}$ is reconstructed using the QE hypothesis from muon angle and momentum



Distributions normalized to a common normalization for the entire φ range

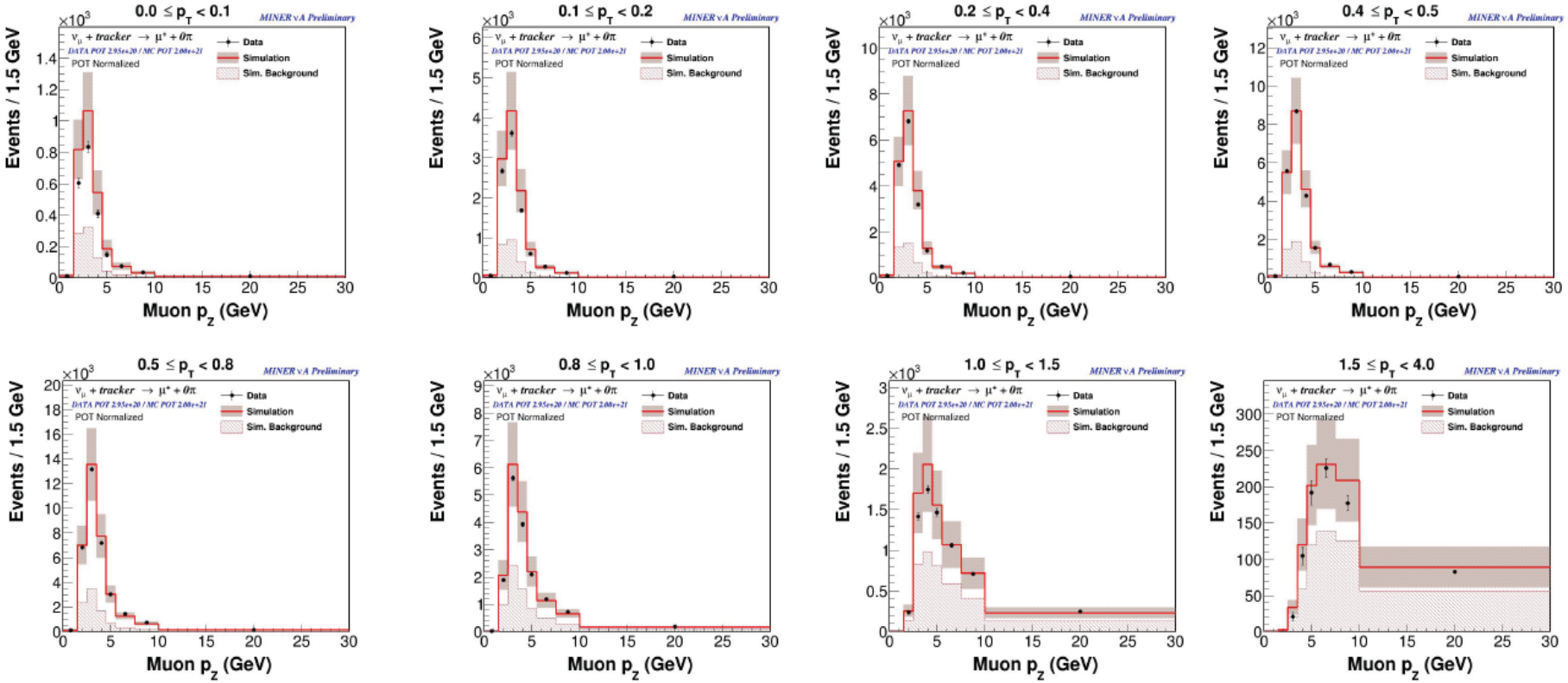
$0 < \varphi < 110$ $110 < \varphi < 160$ $160 < \varphi < 180$

Background for FSI has been tuned and simulation w/o FSI has not been tuned

MINERvA also showing double differential CCQE-like cross sections in p_t and p_z

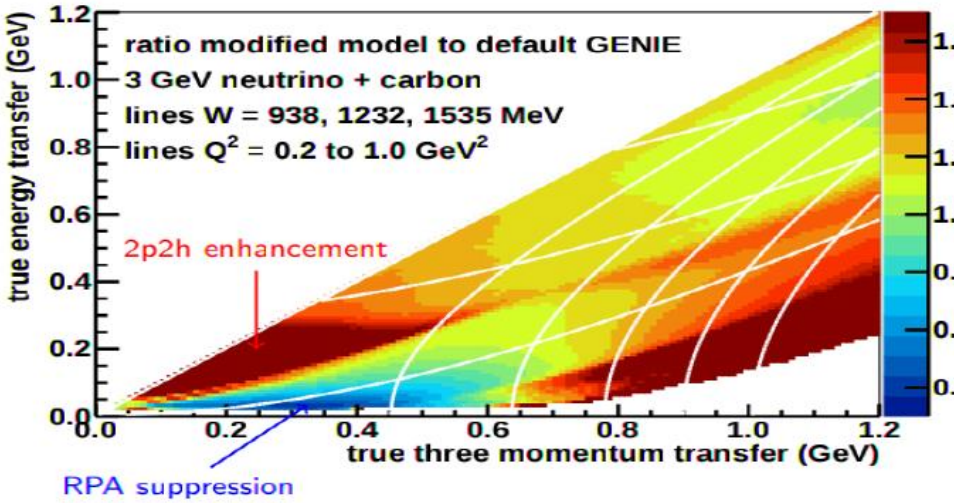
$$\frac{d^2\sigma}{dP_{T_\mu} dP_{Z_\mu}}$$

- Data and simulation event distributions vs. longitudinal muon momentum, in bins of transverse muon momentum

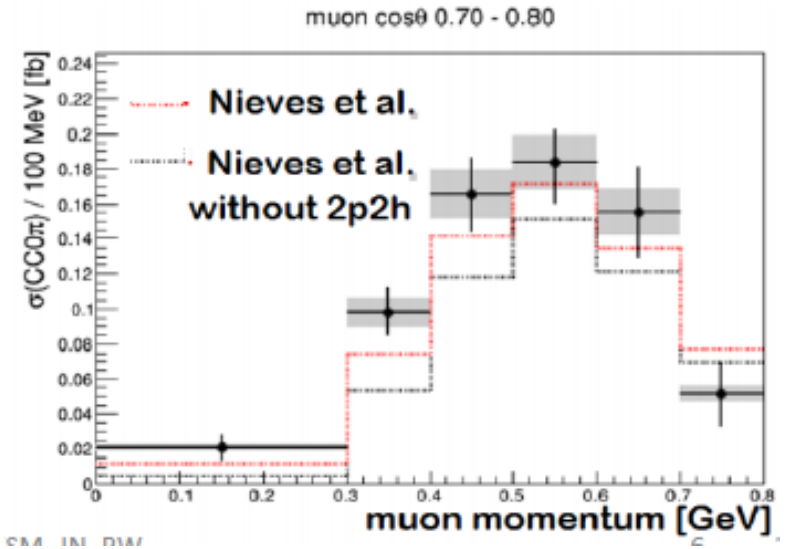


Shown in Betancourt's talk

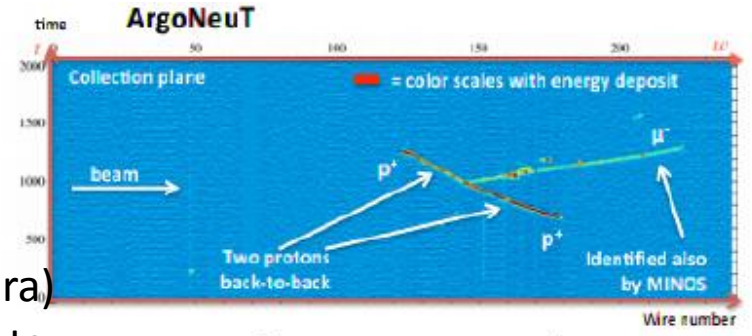
2-body current contribution to CCQE is here to stay



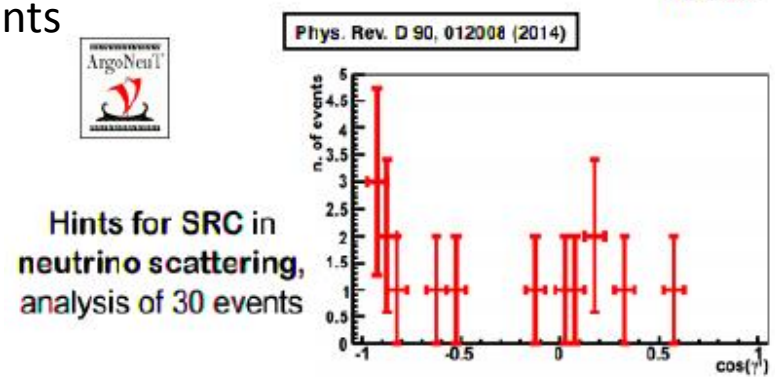
MINERvA (Rodrigues) sees evidence for 2p2h and RPA in νμ cc inclusive events at low momentum transver (ask Rik if you want to know more than you'd really like to know about this!)



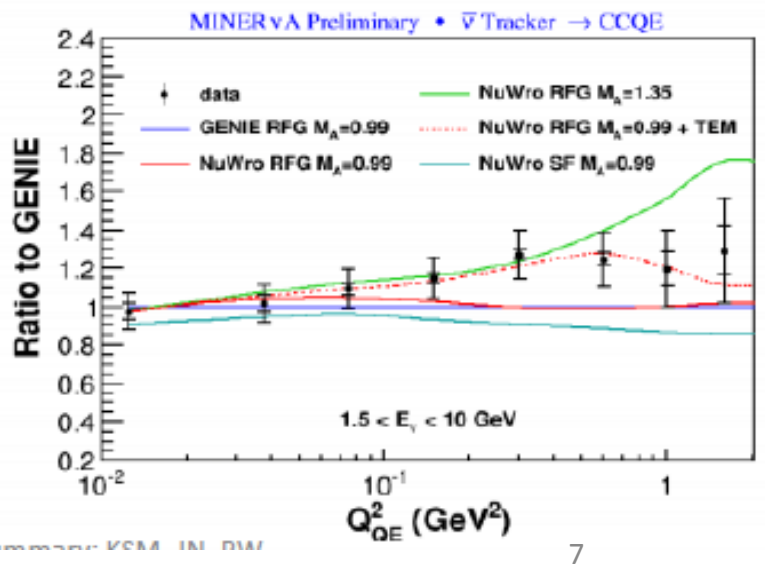
T2K (Redij) sees preference for NEUT with 2p2h in data from 2 different CC0pi analyses (one with mu and p and one with just mu)



ArgoNeut (Palmara) sees mu+2p events and hint of SRC

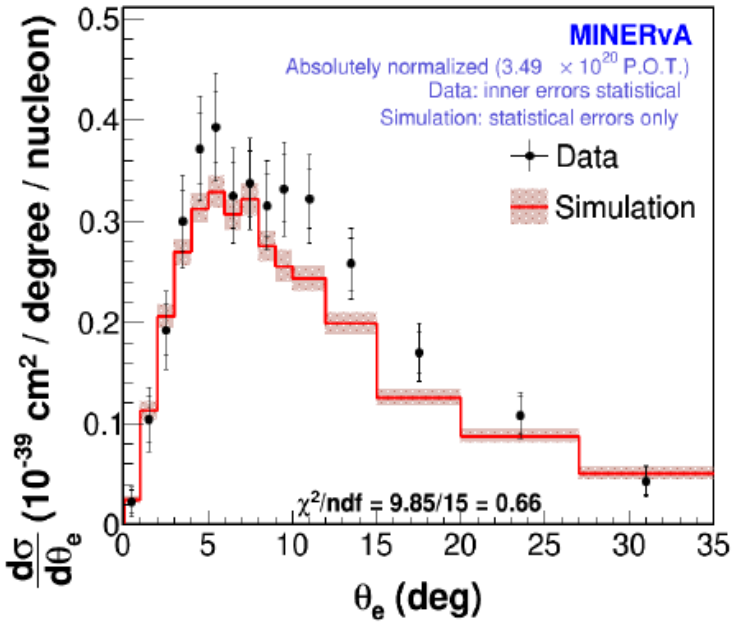


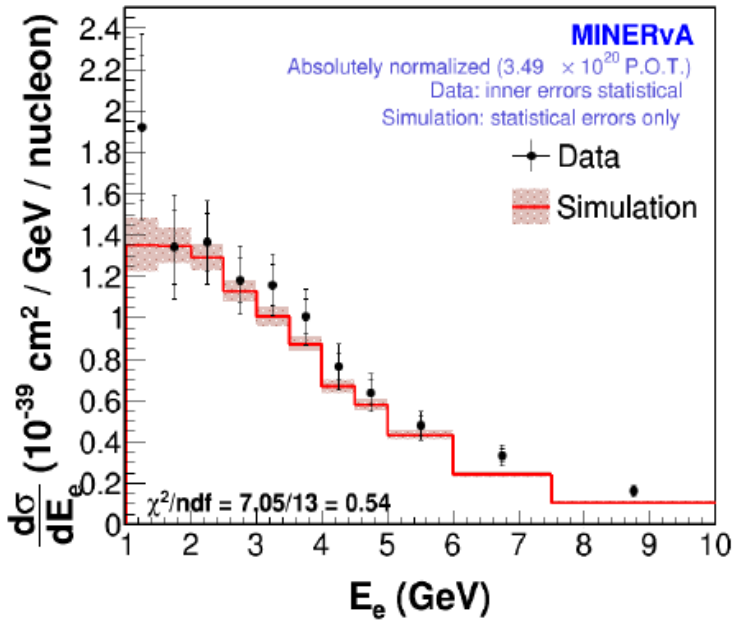
MINERvA (Betancourt) flux revision leads to data having preference for model with TEM

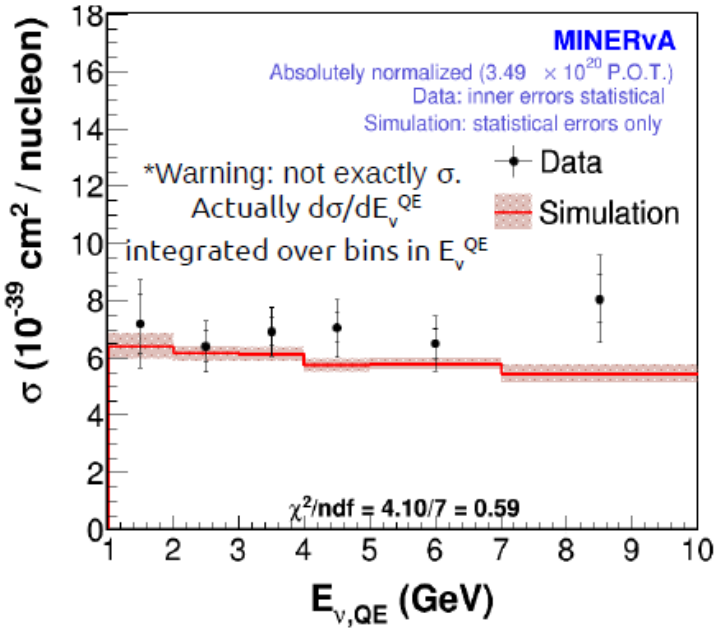


Electron neutrino CCQE-like cross sections

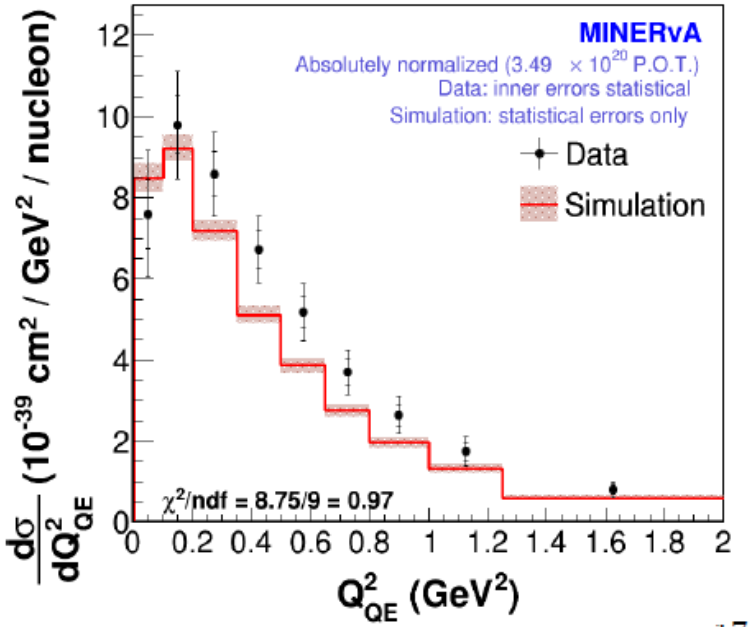
J. Wolcott, Tufts (Rochester Ph.D. thesis work)



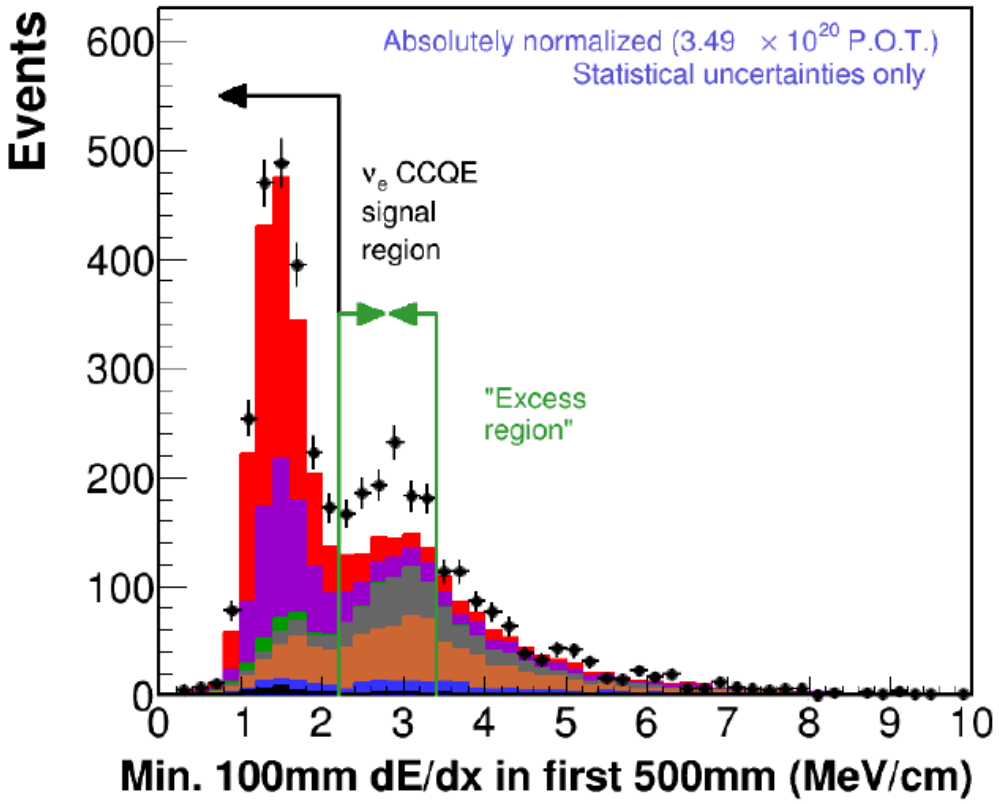


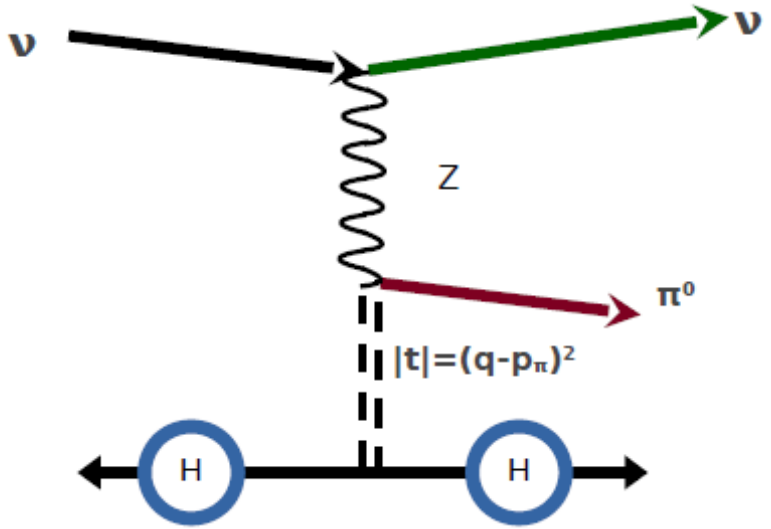


Measured cross-sections are consistent with the prediction from GENIE 2.6.2



Wolcott - MINERvA



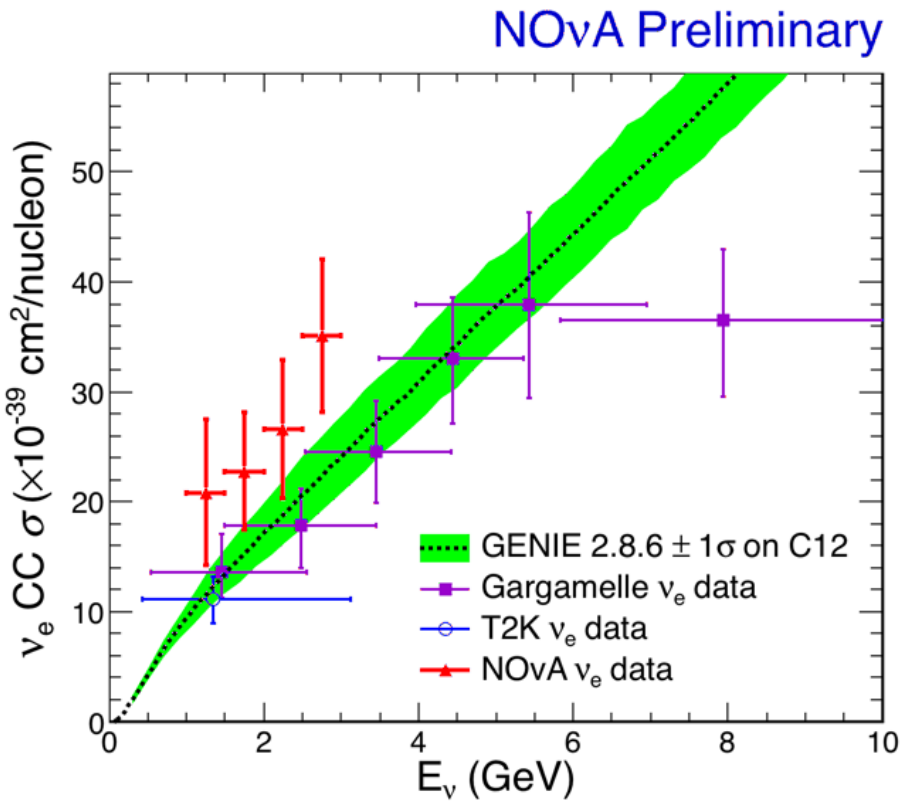


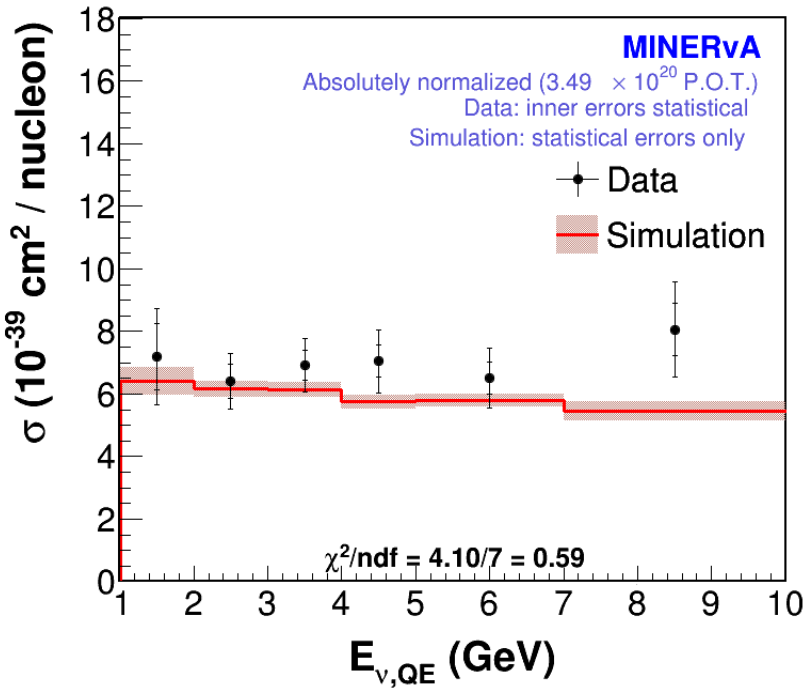
Characterized by subtracting out the GENiE expectation and looking at behavior of region with the excess

Consistent with unmodeled NC diffractive pizero production

Oddly enough, I don't think this has been seen and characterized separately before. Has been part of coherent pizero production signal. Am I missing something here?

New CC inclusive electron neutrino results from NOvA

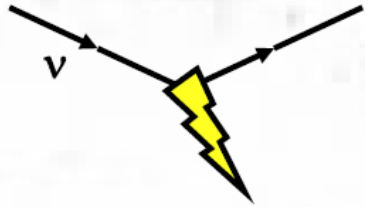




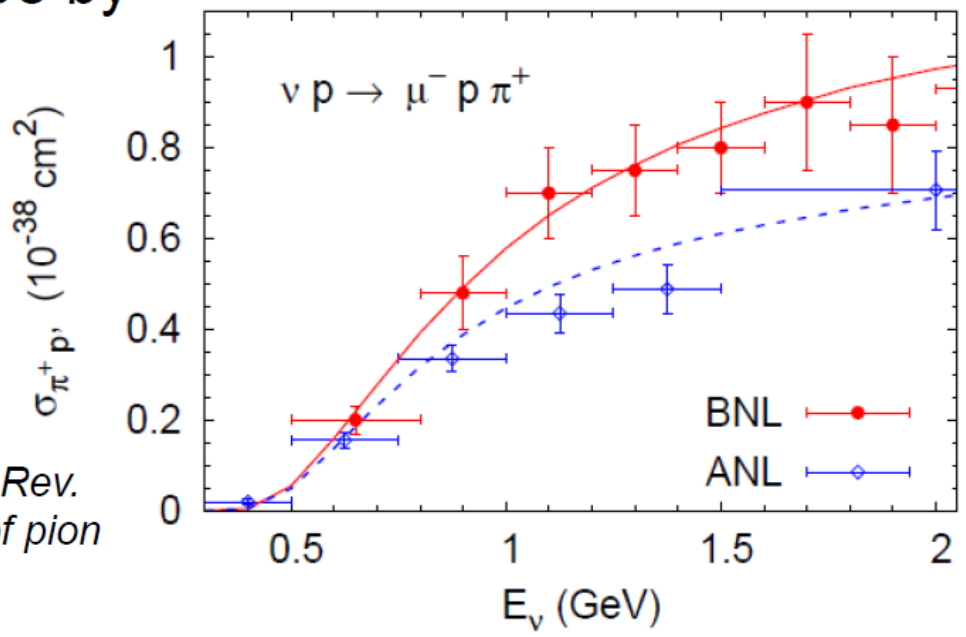
To left is NOvA CC inclusive ν_e.
Above is MINERvA CCQE "σ" for ν_e. Both are consistent with, but systematically higher than GENIE (based on universality with lepton mass correction)

Xuebing Bu (FNAL)

Existing Deuterium Data



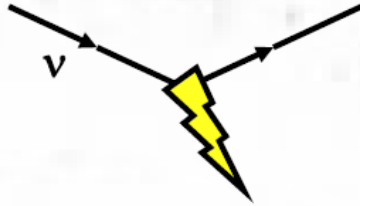
- Two main datasets from H_2 and D_2 bubble chambers, "ANL" [G. Radecky et al., Phys. Rev. D25, 1161 (1982)] and "BNL" [T. Kitagaki et al., Phys. Rev. D34, 2554 (1986)] that comprehensively measure pion production
- Published results disagree by 30-40% and this is a major problem in attempts to extract axial form factors



From O. Lalakulich and U. Mosel, , Phys. Rev. C87, 014612 (2013). Curves are ranges of pion production on D_2 from GiBUU model.

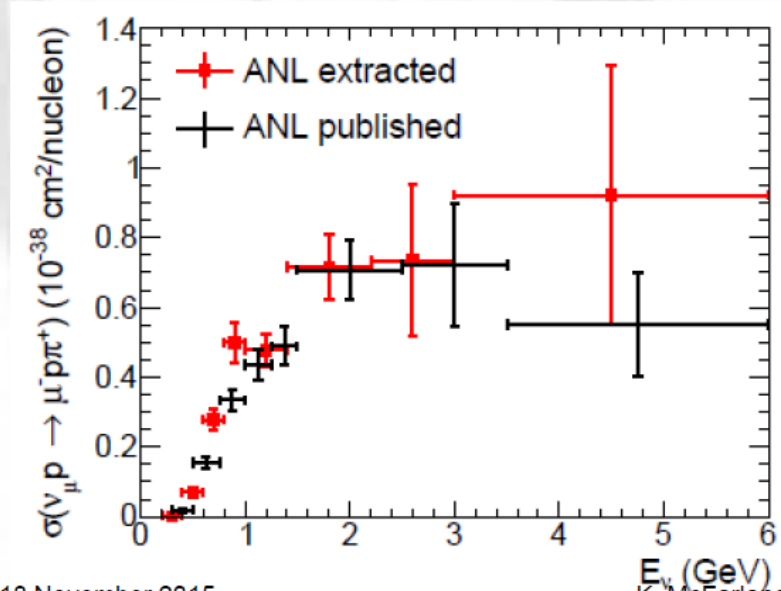
Mcfarland – pion review talk

Resolving the Deuterium "Problem"



Mcfarland – pion review talk

- Both experiments had large and difficult to quantify flux uncertainties. Recent observation: ratios of pion production to other processes are consistent.
  - Therefore "correct" results using reliable predictions of CCQE with axial form factor set by electroproduction of pions. *[C. Wilkinson, P. Rodrigues et al, Phys Rev D90 (2014) 112017]*



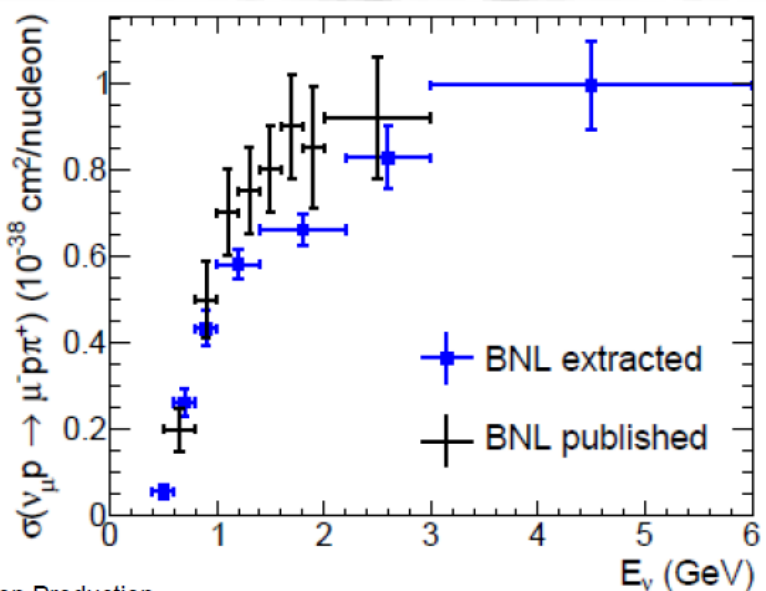


Fig from the paper

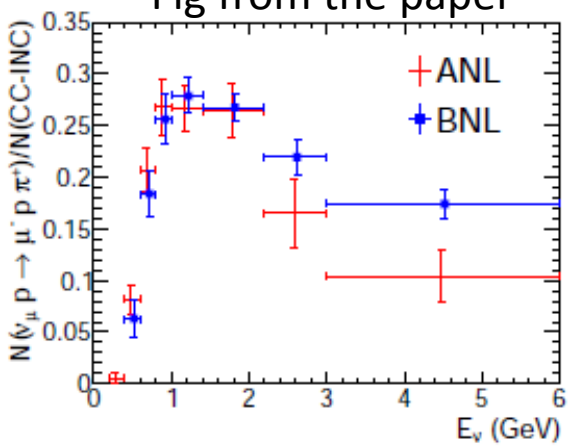
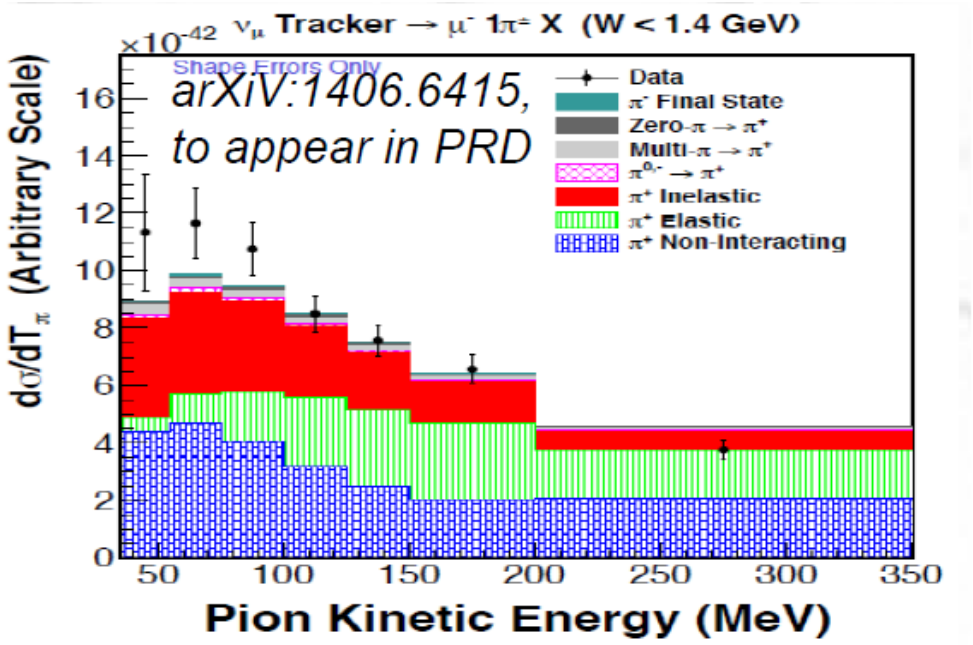
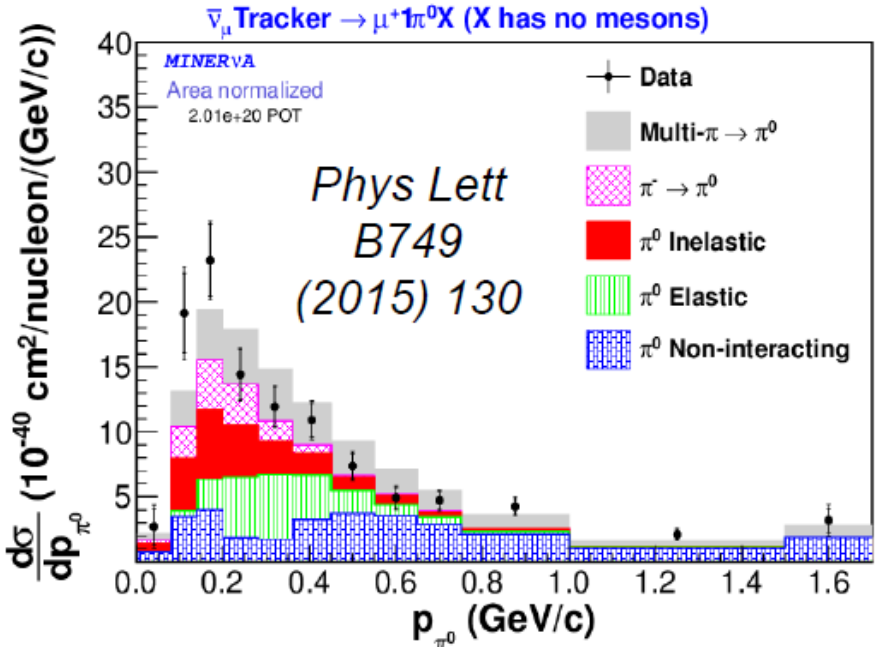
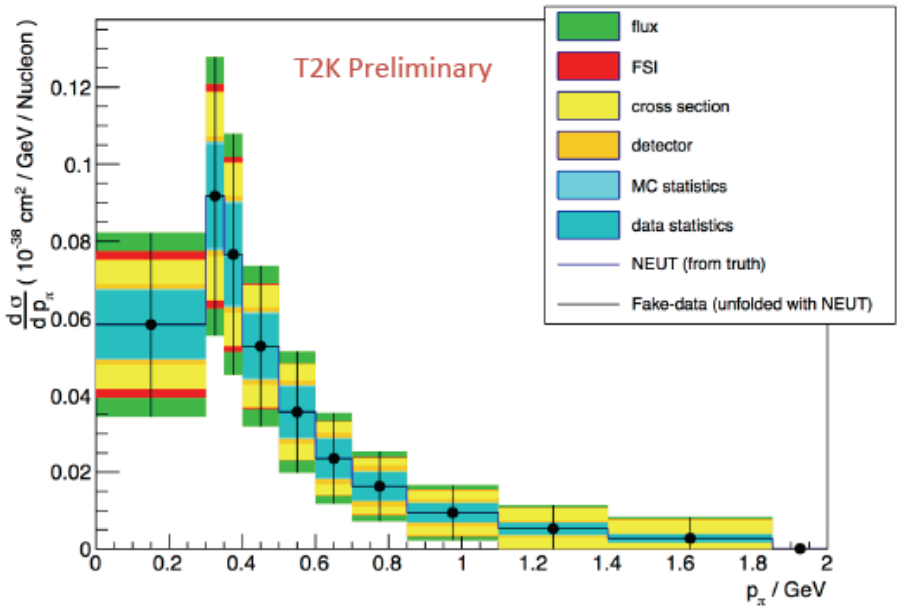


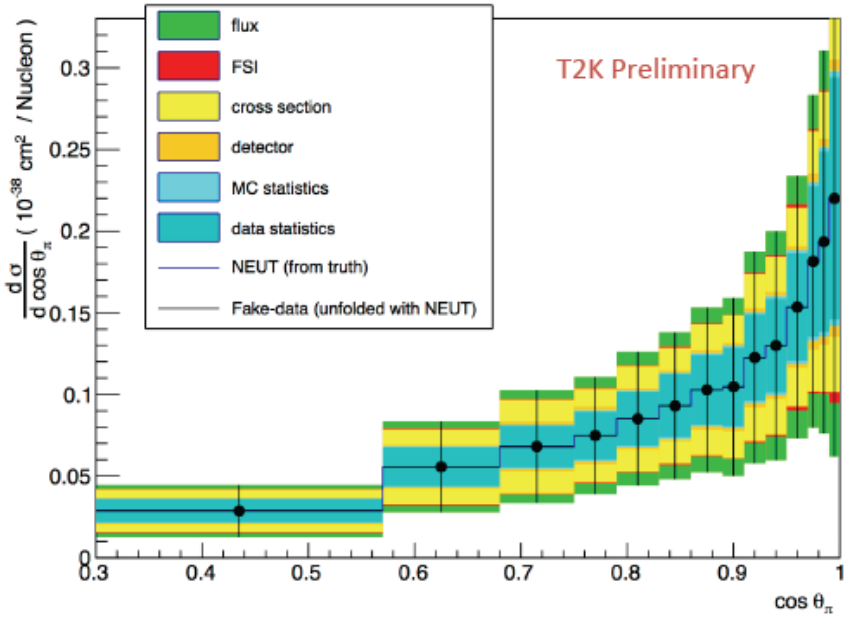
FIG. 4: Ratio of $\nu_\mu p \to \mu^- p\pi^+$ to CC-inclusive events as a function of E_ν for both ANL and BNL.





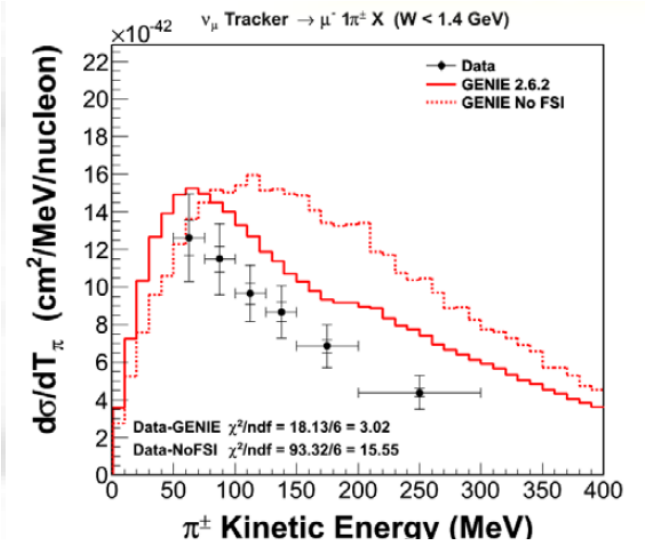
MINERvA charged and neutral pion production

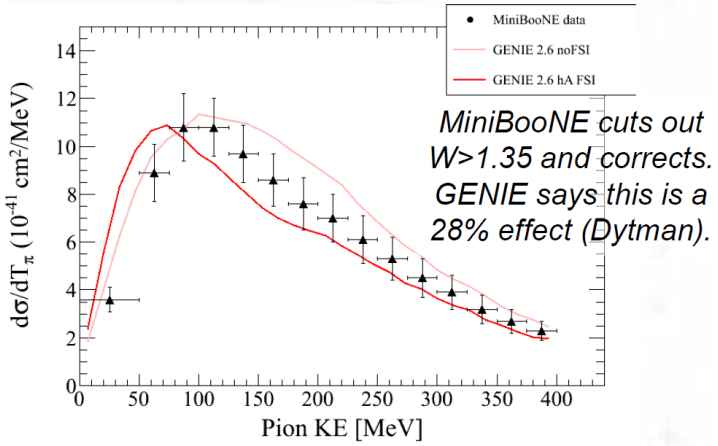




T2K CC1pi+ in water

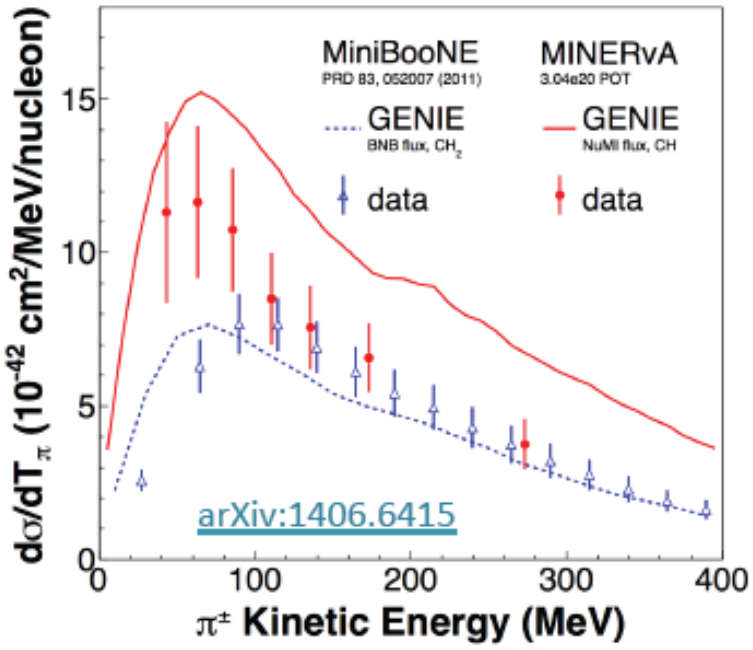
Single charged pion production comparison, tension between MINERvA and MiniBooNE

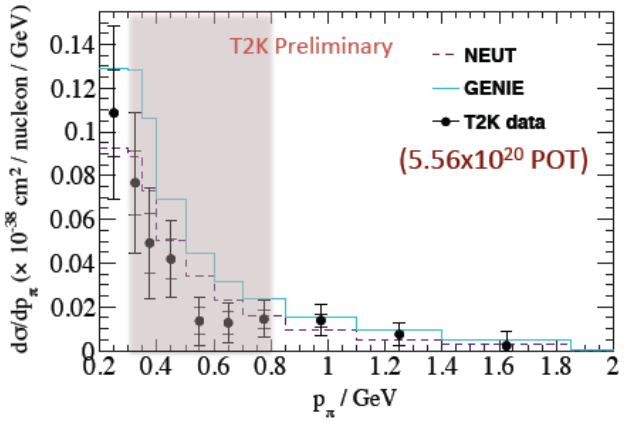




MiniBooNE cuts out W>1.35 and corrects. GENIE says this is a 28% effect (Dytman).

- Even with ~10% flux uncertainties from both experiments, there is ~2σ tension between MINERvA and MiniBooNE
- Shape tension also

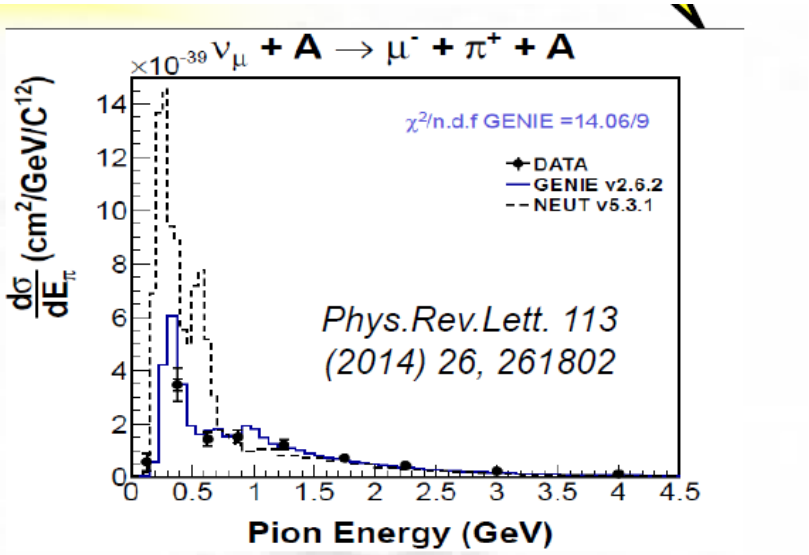


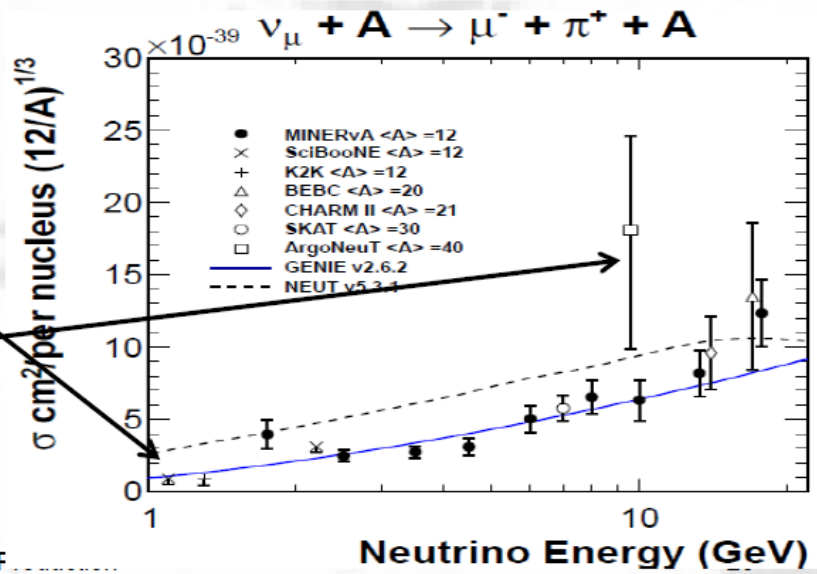


Preliminary result from T2K

Coherent pion production

- Recent MINERvA data *(Phys.Rev.Lett. 113 (2014) 26, 261802)* shows overestimate of low energy pions in generators
- Updating (PRD in preparation)
- Biggest effect of low energy pions is at low E_ν
- Explains non-observations at K2K and SciBooNE?
- Note also recent ArgoNeuT measurement on Ar (low statistics), *Phys Rev. Lett 113 (2014) 261801*

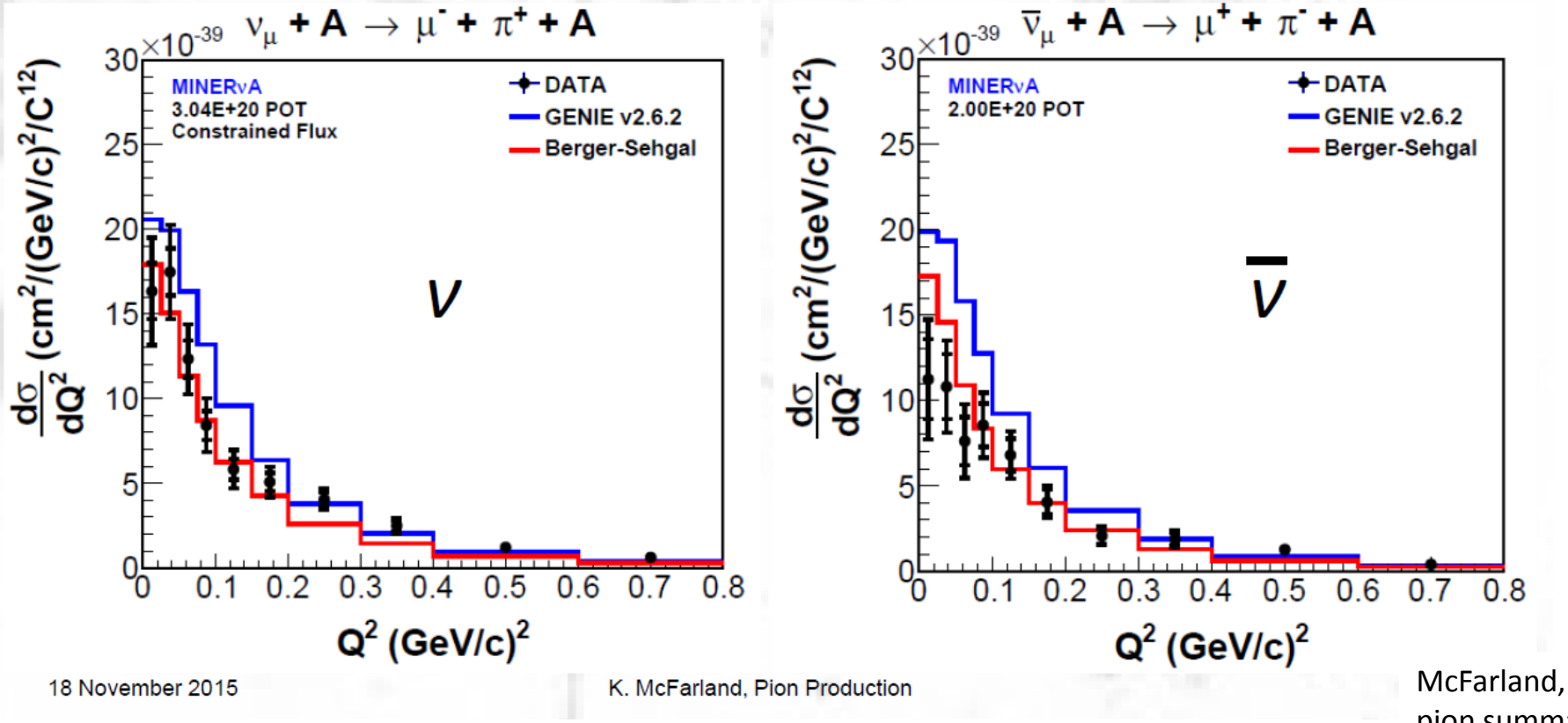


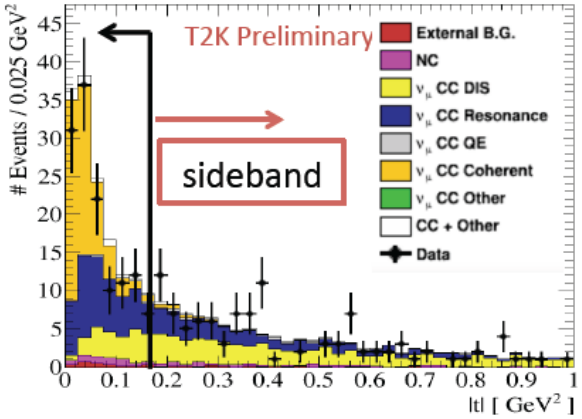


McFarland, in pion summary

Coherent pion production

- Main new result is Q^2 dependence of reaction.
  - PCAC predicts identical cross section at $Q^2 \rightarrow 0$ limit
  - Q^2 distribution is a model-dependent assumption





T2K (Cao) preliminary result sees an excess (2.2 σ)
of events consistent with CC coherent pi+ production

McFarland, in pion summary

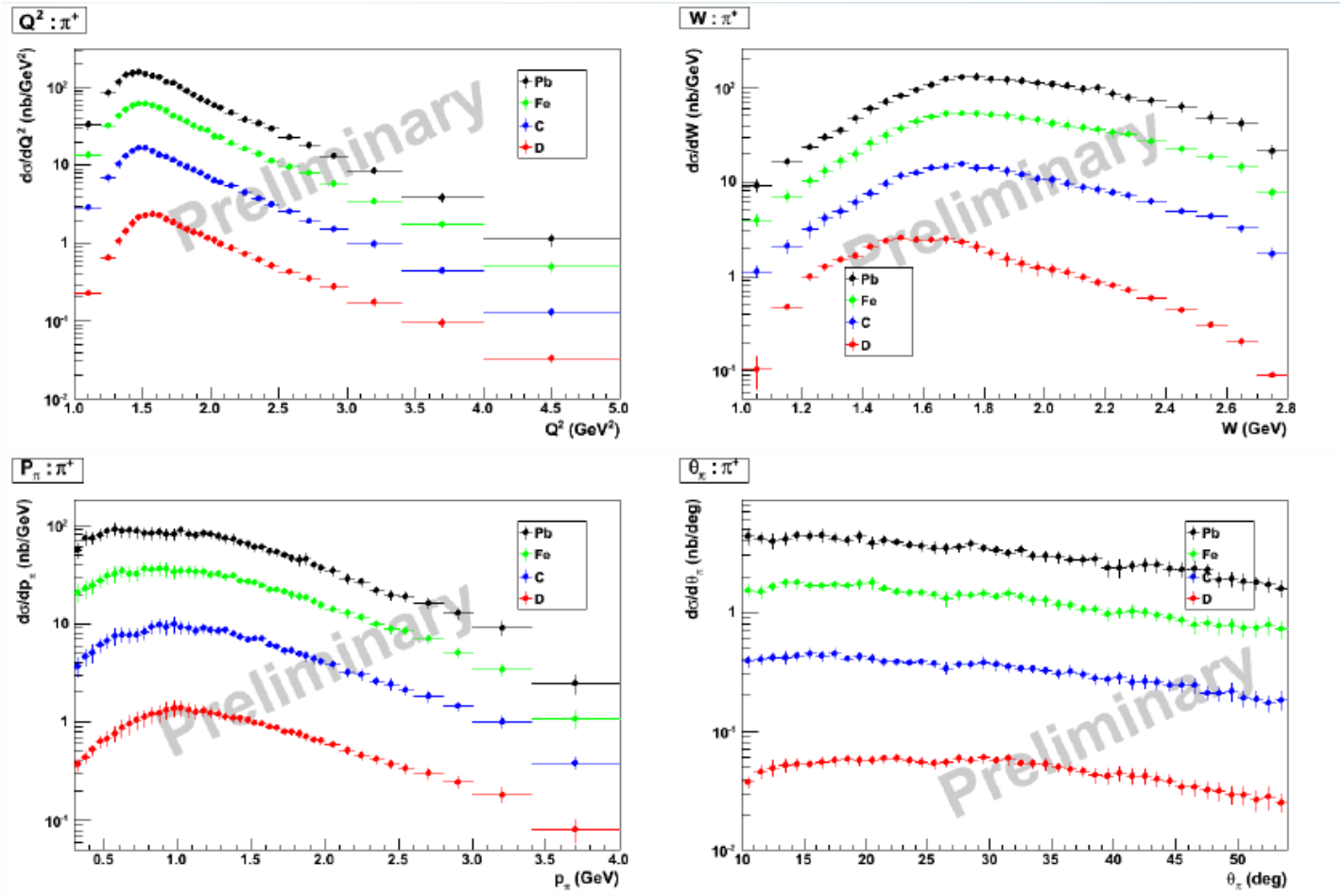
eA, high stats measurement of single pion production cross sections

Jlab CLAS, eg2, 5 GeV electron beam

A=D,C,Fe,Pb

Xsecs produced in +,-,W,Q^2,pion momentum, pion angle

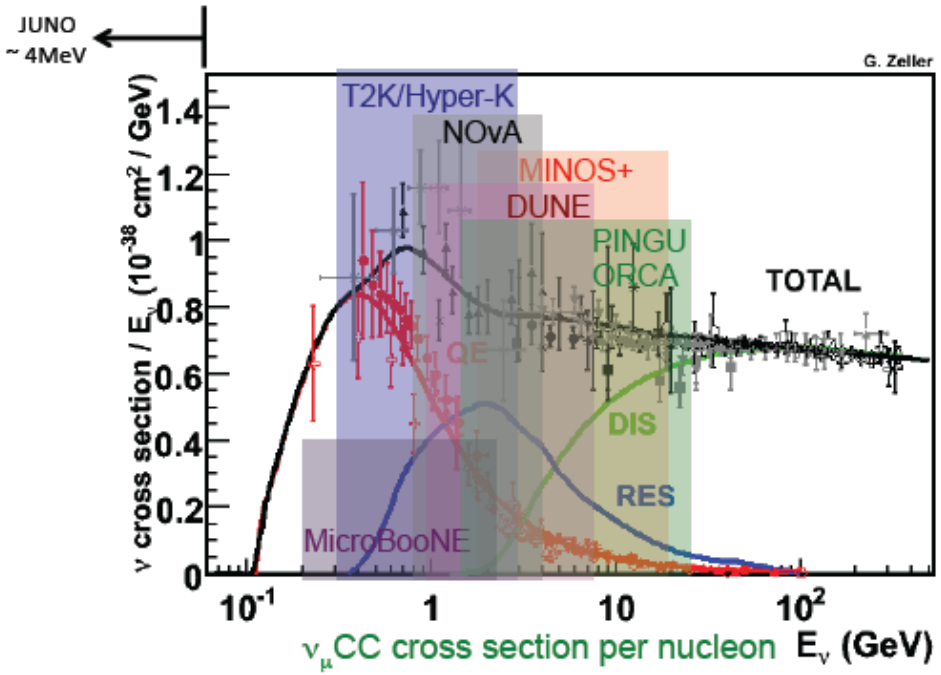
Hyupwoo Lee
(Rochester)



Might be helpful for FSI studies. Pions produced inside nucleus potentially different from pion beam scattering off nuclei for MC tuning. GENIE has an eA mode, BTW.

"final-ish" - starting collaboration review, hope to publish in early 2016

Teppei Katori



AGKY, EPJC63(2009)1
TK and Mandalia,JPhysG42(2015)115004

1. GENIE hadronization model (AGKY model)

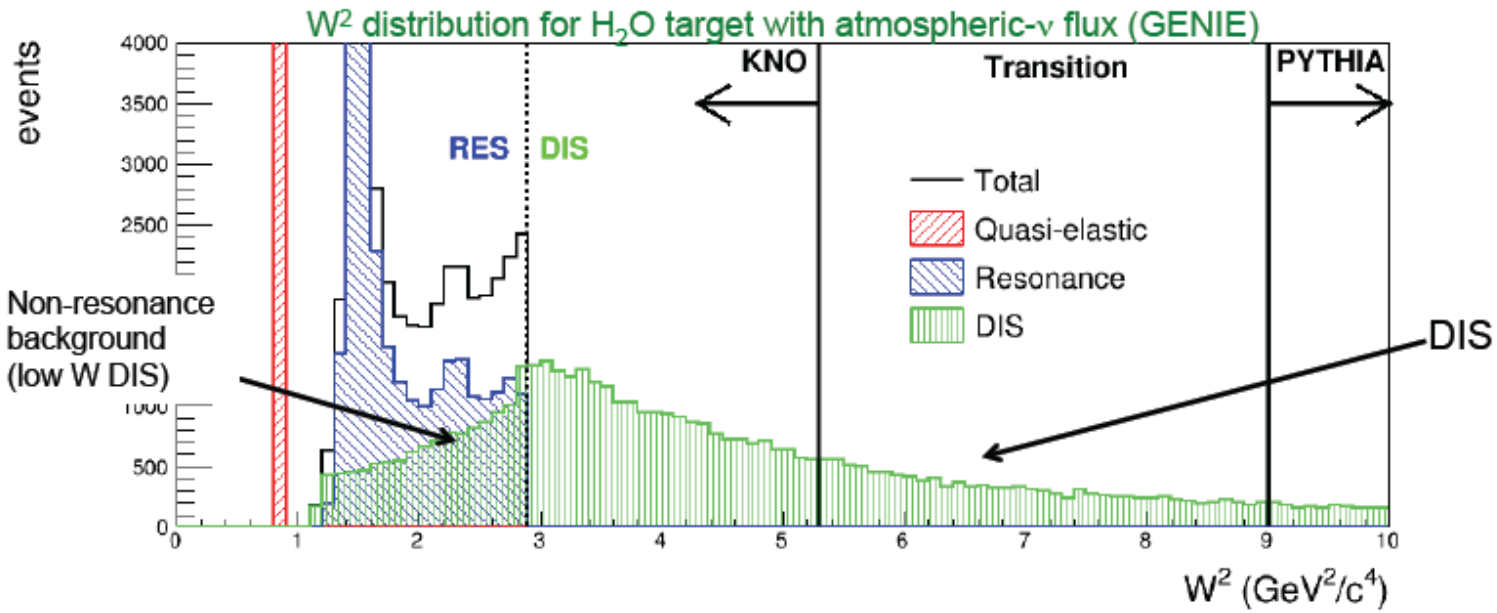
Cross section

W^2<2.9 GeV^2 : RES
W^2>2.9 GeV^2 : DIS

Hadronization (AGKY model)

W^2<5.3GeV^2 : KNO scaling based model
2.3GeV^2<W^2<9.0GeV^2 : transition
9.0GeV^2<W^2 : PYTHIA6

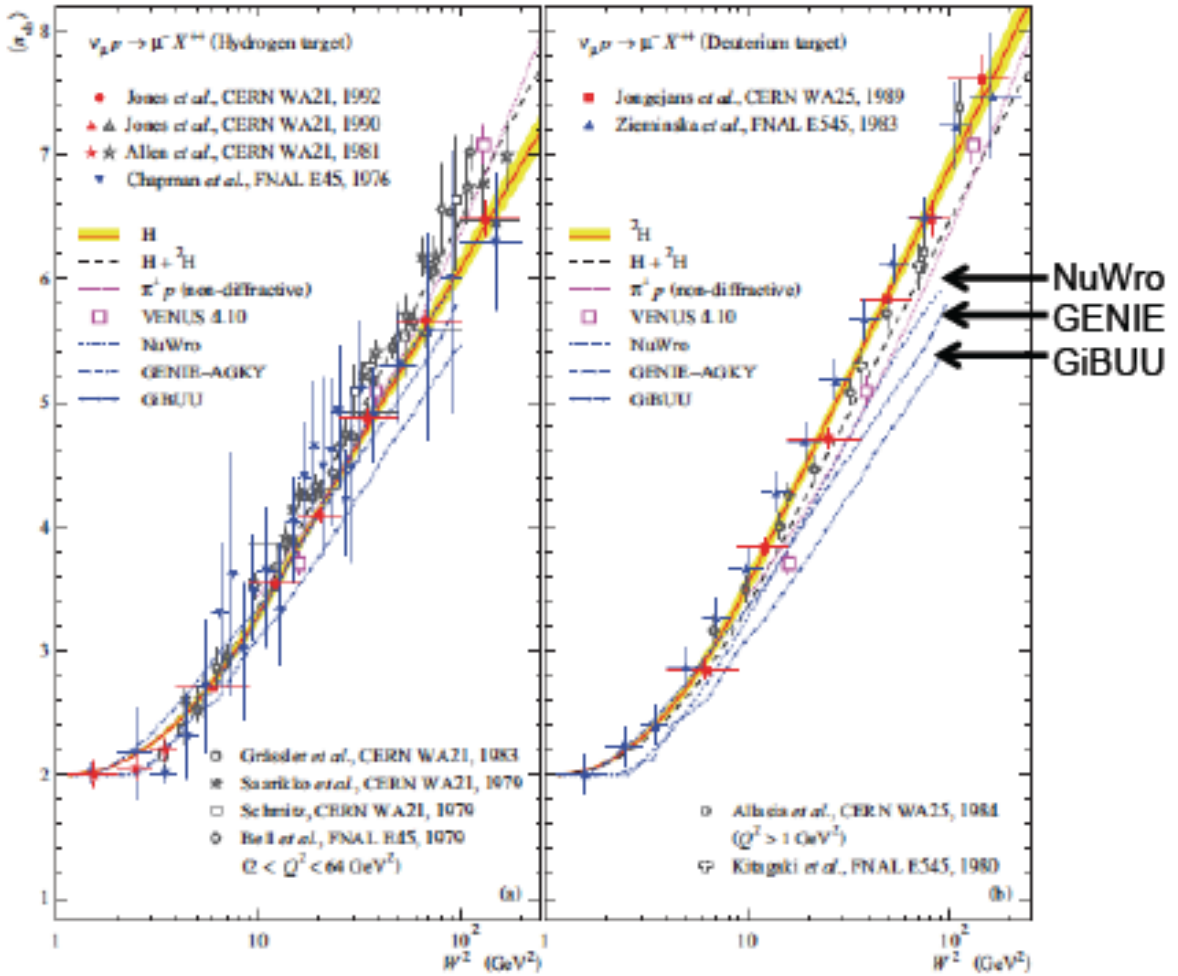
There are 2 kind of "transitions" in SIS region
- cross-section
- hadronization



The neutrino MC's that use PYTHIA 6 systematically underestimate the charged hadron multiplicity of DIS events.

Need to tune

TK working on putting PYTHIA 8 into GENIE (maybe next model release in 2016)



Average charged hadron multiplicity with function of W^2